Structural and Mechanical Functions of Bones, Muscles, and Joints by use of 3D Models in Veterinary Medical Education

Product Design Specifications

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Function:

The device is a model of the forelimb of a medium sized dog for the use of first-year veterinary students. The model uses 3D modeled bones and created muscles to replicate the connections, functions, and appearance of the full limb of the dog. The model should be easily used by the students to get an understanding of muscle connections and purposes.

Client Requirements:

- The client requests an anatomically correct model of a dog's forelimb with accurate bone structure and functional muscles and removable muscle attachments
- Must have all muscles represented for the forelimbs
- Must be durable enough to withstand usage throughout four weeks, four times a week from around 100 students
- Must differentiate between muscle and tendon on the model
- The muscles on the model must be easily detached and reattached to the tendons to represent the movement across the joints
- Opposing muscles across joints must not overpower the other, so balancing tensile strength is key

Design Requirements:

1. Physical and Operational Characteristics
a. *Performance Requirements:*

The device will be used four times a week by roughly 100 first-year veterinary students for the first four weeks of the fall semester (16 times annually). This is not accounting for unscheduled usage.

b. *Safety:*

The primary safety concerns of this device are the muscles causing either the bone or muscle to snap towards an individual using the device, or the device not remaining sanitary after being used by many students repeatedly touching and using the device.

c. *Accuracy and Reliability:*

The device should be able to accurately represent the anatomical bone and muscle connections of the forelimb of a medium-sized dog. The device needs to have muscle connections that can reliably be removed and added hundreds of times a day with no significant change in strength or connection.

d. *Life in Service:*

The model must be able to withstand usage throughout a four-week period, four times a week, from over 100 students each year. These periods of time would involve near constant removal and attachment of the muscles, so the attachments must not wear down over time.

e. *Shelf Life:*

The model must be able to maintain functionality during nearly a year in storage, without the attachments wearing down.

f. *Operating Environment:*

The model will be exposed to normal room temperatures of around 72 degrees Fahrenheit and typical conditions of around 30 to 60 percent humidity. The device will be highly used for some periods of time and will go long periods of time without use.

g. *Ergonomics:*

Opposing muscles must have equal tensile strengths, and tensile strengths must allow the user to be able to easily remove and attach the muscles.

h. *Size:*

The size of the model has no true restrictions. However, a larger muscle will cost more, and a smaller muscle will make accuracy and strong connections more difficult. The client suggested modeling from a medium sized dog such as a retriever or pit bull.

i. *Weight:*

No weight requirements given by the client; weight will be dependent on the selected size.

j. *Materials:*

The material used for the bone must be durable and able to be 3D printed. A plastic filament such as PLA will likely be used. The material for muscle must have the same qualities as the muscles of the animal. The material needs to provide spring force and be able to snap back to its original shape without any issues over heavy usage.

k. *Aesthetics, Appearance, and Finish:*

The model will be formed accurately to the bone and muscle structure of a medium-sized retriever. The bones will be colored white/off-white with rough texture. The muscles and tendons will be textured as similar to a living muscles and tendons as possible while having easily differentiable colors.

2. Production Characteristics

a. *Quantity:*

One model forelimb of a canine will be produced; more if time allows for it.

b. *Target Product Cost:*

The budget given is $500, but more can be allotted if a larger quantity of limbs is created.

3. Miscellaneous

a. *Standards and Specifications:*

There are no standards- neither national nor international- to meet because the product will not be patented or regulated by the FDA.

b. *Customer:*

The customer liked the start of the previous year's model. They will go into further detail when we meet in person with the model next week on all of their big likes and dislikes of the model.

c. *Patient-related Concerns:*

This device is recommended to be cleaned with non-alcoholic cleaners as many students will be touching and manipulating the model within a short amount of time. It should be cleaned more often during frequent use to help prevent unsafe bacteria and viruses from collecting and transmitting from the device.

d. *Competition:*

There are similar competitions with this device that our client has access to. The devices mimic the muscles with elastic bands instead of the designed muscles.

References